TR 65-96

TECHNICAL REPORT NO. 65-96

OPERATION OF THE TONTO FOREST SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 1, Project VT/5055

1 May through 31 July 1965

Sponsored by

Advanced Research Projects Agency

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GEOTECH

THE GEOTECHNICAL CORPORATION

3401 SHILOH ROAD GARLAND, TEXAS

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3401 Shiloh Road
Garland, Texas

10 August 1965

IDENTIFICATION

AFTAC Project No: VELA T/5055
Project Title: Operation of TFSO
ARPA Order No: 624
ARPA Program Code No: 5810
Name of Contractor: The Geotechnical Corporation
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ABSTRACT

This is a report of the work accomplished on Project VT/5055 from 1 May through 31 July 1965. Project VT/5055 includes the operation, evaluation, and improvement of the Tonto Forest Seismological Observatory (TFSO) located near Payson, Arizona. It also includes special seismological investigations using data derived from eight Long Range Seismic Measurements Project (LRSM) seismological stations.

OPERATION OF THE TONTO FOREST SEISMOLOGICAL OBSERVATORY

1. INTRODUCTION

1.1 AUTHORITY

This research was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center under Contract AF 33(657)-14444. The contract was dated 12 April 1965; the statement of work for Project VT/5055 is included as an appendix to this report.

1.2 HISTORY

Tonto Forest Seismological Observatory (TFSO) was originally constructed by the United States Corps of Engineers in 1963. TFSC was designed to record all types of seismic events and to be used as a laboratory for testing, comparing, and evaluating advanced seismograph equipment and seismic recording techniques. The instrumentation was assembled, installed, and operated until 30 April 1965 by UED Earth Sciences Division of Teledyne Systems Company under Contract AF 33(657)-7747. In March 1964, the Long Range Seismic Measurements (LRSM) Program provided eight mobile seismic recording vans to extend the existing instrument arrays at TFSO. On 1 May, The Geotechnical Corporation (Geotech) assumed full operation of TFSO.

The location of TFSO, the LRSM extended array sites, and the TFSO buildings are shown in figures 1 and 2.

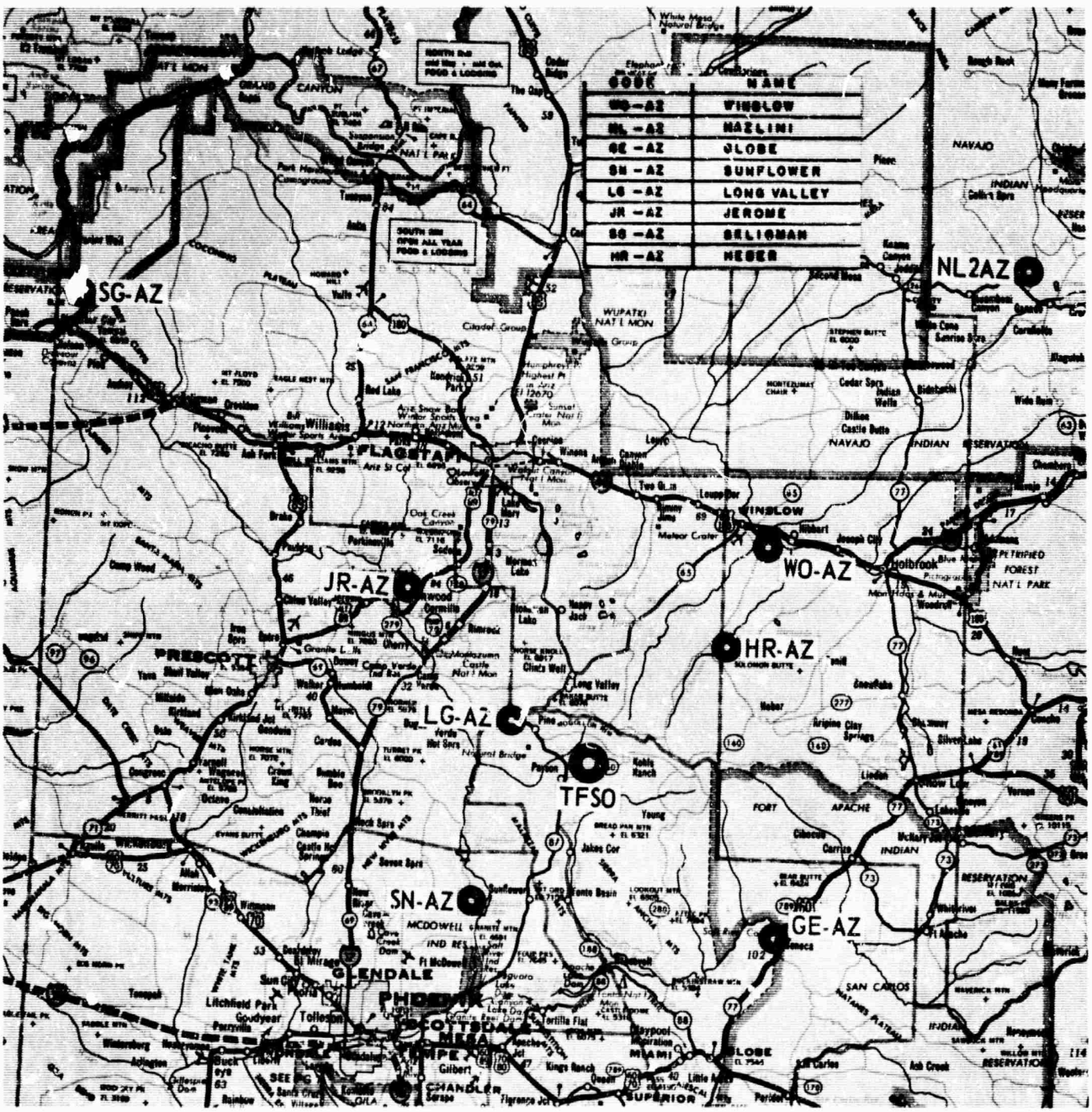

Figure 1. Locations of TFSO and extended array sites

2. OPERATION OF TFSO

2.1 GENERAL OPERATION (Task 1a)

2.1.1 Take-Over of TFSO Facilities by Geotech

Four Geotech employees went to TFSO on 19 April to become familiar with the instrumentation and routine operating procedures prior to the transfer of the observatory operating responsibility from Teledyne to Geotech. The Teledyne personnel were quite helpful during the orientation period. A smooth transition of routine operations and change of personnel was completed by 1 May.

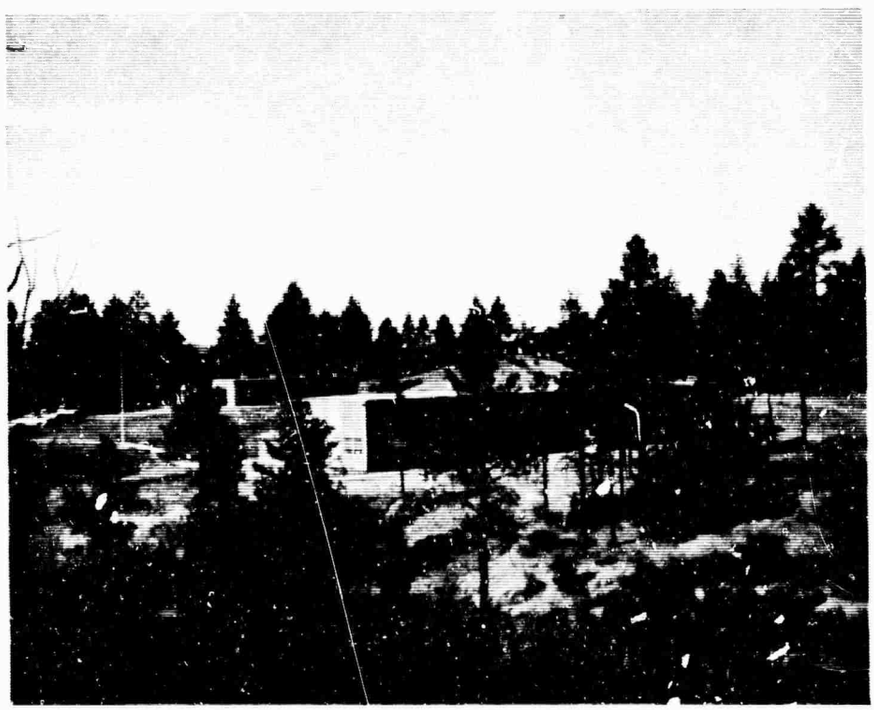

Figure 2. TFSO, looking southwest

Just prior to the changeover, the Project Officer, Captain Clent Houston, visited TFSO and reviewed the facilities with both Teledyne and Geotech representatives. The Project Officer told Geotech personnel what AFTAC expected regarding completeness of operational logs and records and the sending of messages and data. He also discussed special studies underway or planned.

2.1.2 Inventory of Equipment and Real Property

Mr. W. O. Grimpe, Headquarters, Aeronautical Systems Division, Wright-Patterson Air Force Base, visited TFSO on 27 April to inspect facilities. The facilities inventory was checked on 28 April and the contract equipment inventory was signed on 30 April.

Mr. Thomas Muir, Real Property Clerk from Williams Air Force Base, was at TFSO on 22 July to make a Real Property Inventory. All of the original TFSO real property inventory records were changed to show any subsequent improvements. While Mr. Muir was at TFSO, he also updated the original building drawings to show the modifications and additions that had been made to the facilities.

2.1.3 Security Inspection

On 21 July, Mr. D. P. Posage, Security Inspector from the Western Contract Management Region, San Diego Office, visited TFSO. The purpose of his visit was to inspect the facilities before issuing a SECRET facility clearance for TFSO. All was in order, including the standard practice procedures observed at TFSO. Mr. Posage stated that clearances of all personnel would have to be transferred. This is presently being done.

2.1.4 Application for Radio Licenses

Radio licenses for transmittal of data from the sites of the LRSM extended array to TFSO were obtained by 1 May. The close liaison with the Federal Communications personnel by the Project Officer was most helpful in obtaining the licenses on schedule.

Telegraphic approval was received on 22 June from the Federal Communications Commission to operate the five-station citizens band radios until 22 September on a temporary permit. On 28 June, the permanent license was received and the call sign is KMV 4469.

2.1.5 Visit by Messrs. H. E. Klinkert and C. P. Fink

Mr. H. E. Klinkert, Small Business Administration, and Mr. C. P. Fink, Phoenix Contract Management Officer, visited TFSO on 30 June. They informed TFSO personnel that all purchase orders for major items issued from TFSO must be checked by their offices. After being informed that all major purchases were handled through the Garland office, Messrs. Klinkert and Fink stated that further close liaison between TFSO and their offices would not be required.

2.1.6 Visit by Captain Houston, Captain Munzlinger, and Mr. Leichliter

Captain Clent Houston, Captain Frederick Munzlinger, and Mr. B. B. Leichliter arrived at TFSO on 23 June and left on 24 June. The purpose of the visit was to enable Captain Houston to make his final inspection of TFSO and to orient Captain Munzlinger with the routine operation of TFSO, to familiarize him with the facilities, and to review the status of Project VT/5055. Mr. Leichliter returned to TFSO on 27 June and left for Garland on 29 June.

Captain Munzlinger assumed responsibility as AFTAC Project Officer for Project VT/5055 on 1 July.

2.1.7 Completion and Shipment of Station Logs, Film, and Magnetic Tape

The magnetic-tape seismograms are shipped from TFSO directly to the user each week. Three of the magnetic-tape units are for TFSO use (AFTAC control) and three are for university use. When an AFTAC-supported contractor is not using all three magnetic-tape units, the observatory notifies AFTAC.

Film from nine Develocorders are shipped weekly to the user when requested. At the present time three Develocorders are used by AFTAC-SDL. Data recorded on four Develocorders are shipped monthly to Garland. The film and magnetic-tape logs are made up in 14 duplicate sets. TFSO switched to new logs, approved by AFTAC, on 7 July. Sets of typical Develocorder record prints are sent to Geotech regularly and to other users on special request.

2.2 EVALUATE SEISMIC DATA AND DETERMINE OPTIMUM OPERATIONAL CHARACTERISTICS (Task 1b)

2.2.1 Vault Retrofit Project

2.2.1.1 When Geotech personnel inspected TFSO, they found that the short-period seismographs and instrument vaults would have to be modified if optimum seismograph performance were to be achieved. Some features of the short-period vaults that required attention were:

a. Several tank vaults contained water.

b. The vault lids were made of a circular piece of 6.4 mm steel held to the vault with only four anchor bolts and providing an inadequate seal against wind and water.

c. The vaults were sealed with a soft putty-type gasket material which is water absorbent and not adequate gasket material for sealing vaults.

d. The cable inlet tee threads were not sealed properly and the cable inlet was filled with a sealant which is water absorbent.

2.2.1.2 A program to modify the short-period vaults was started in June. Retrofit of the horizontal short-period vault was completed on 20 July. The major improvements made were:

a. The lids were notched to accept the eight additional anchor bolts and reinforcements were welded to the lids (see figure 3).

b. Eight bolts were welded to the outside of each tank vault.

c. The pipe conduit was replaced and cable ways were sealed with Chico A5 cement.

d. A permanent-type vault lid gasket was installed (see figure 4).

At the end of the reporting period, similar modification of the vertical short-period vaults was in progress.

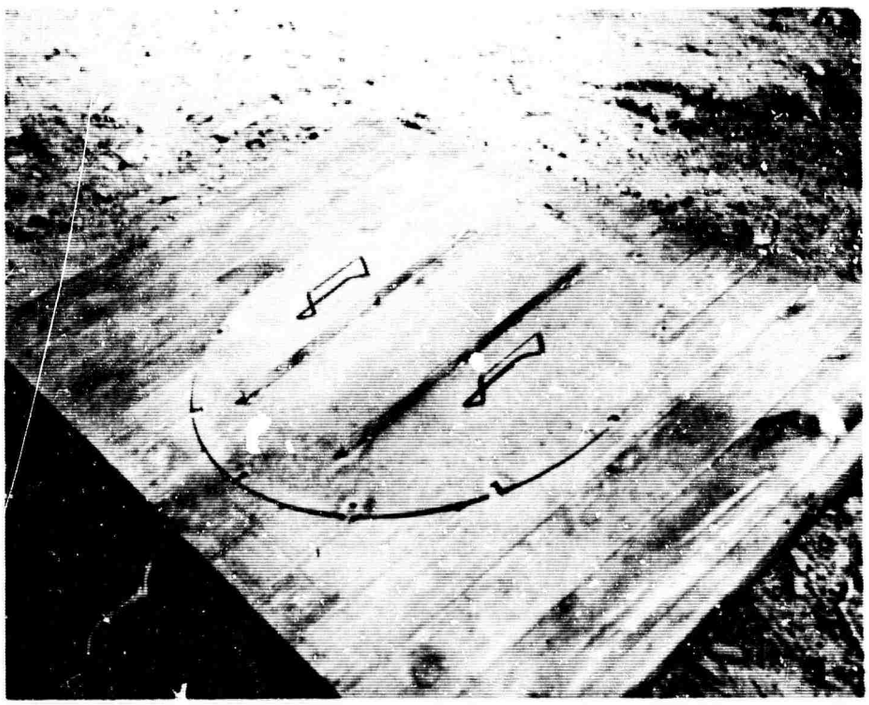

Figure 3. Modified vault cover

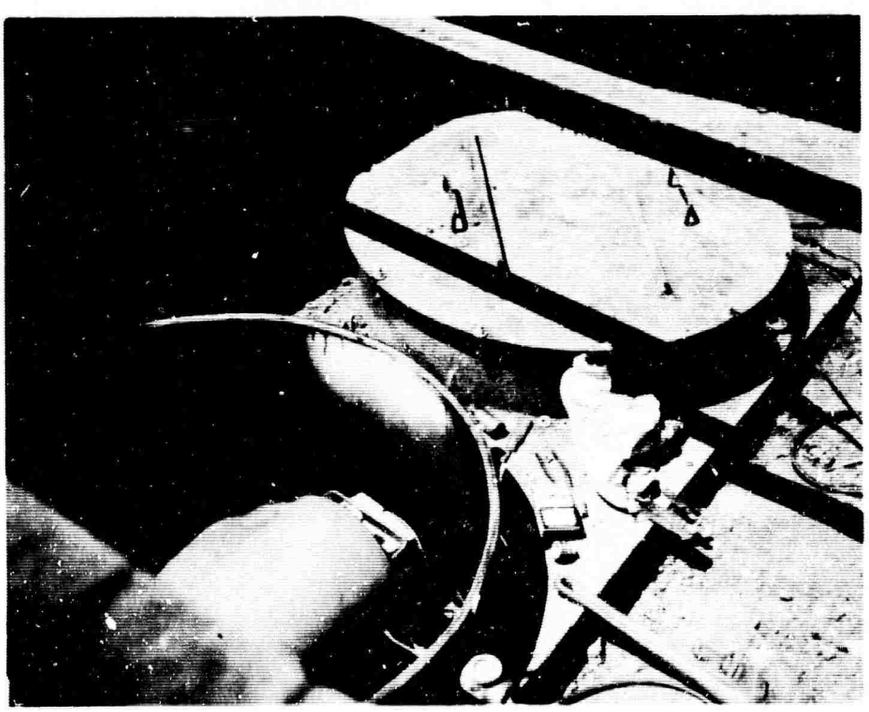

Figure 4. Vault after retrofit

2.2.2 Installation of the AEI Lightning Protection System and Reported Storms and Storm Damage

After reviewing the lightning protection system at TFSO, Geotech recommended that the existing system of carbon blocks and fuses be modified by removing the carbon blocks and installing Associated Electronics Industries, Limited (AEI) Type 16A lightning protectors in the lightning protection system. The AEI lightning system was designed and successfully operated at the Wichita Mountains Seismological Observatory near Lawton, Oklahoma.

The modifications of the lightning protection system at TFSO was begun on 31 May. The protectors were replaced first at the seismometer end of the data lines and then at the central-recording building (CRB) end of the data lines. During replacement the cables were all distinctly marked.

The first moderate storm near TFSO occurred on 23 June. Only the anemometer near Z30 was damaged during this storm.

Many minor electrical storms occurred during July. A major storm occurred on 10 July. Most of the damage to the system was confined to those systems that were not yet protected by the AEI lightning protection system. Equipment damaged on 10 July is listed in table 1. Of the 25 circuits affected, 17 (86 percent) were calibration circuits that were not protected by the AEI system at the CRB. Of the remaining 8 circuits, 6 were data circuits that were not protected by the AEI system at the vault protector, but the data lines were protected at the CRB. Therefore, only 2 of the 25 circuits affected were protected on both ends by the AEI protection system. These were data lines Z69 and Z18.

Analysis of the failure of these two AEI-protected circuits (Z69 and Z18) indicates that neither failure could be attributed to failure of the AEI protection system. The diodes in the power supply of the Z69 data line failed, probably because of a power surge during transfer of the current load from commercial power to the standby generator.

In the other data line (Z18), the galvanometer diode protector part of the lightning protection system failed but the AEI lightning protector did not.

By the end of July, the AEI lightning protectors were installed in the following:

Table 1. Equipment at TFSO damaged on 10 July

System	Circuit	Fuses	Carbon blocks	Galvo diode protector	
Z2	Cal	X	X		
Z3	Cal	X	X		
Z5	Cal	X	X		
Z7	Cal	X	X		
Z8	Cal	X	X		
Z9	Cal	X	X		
Z13	Cal	X	X		
Z18	Cal	X	X		
Z18	Data			X	
Z22	Cal	X	X		
Z37	Cal	X	X		
NBB39	Cal		X		
NBB39	Data		X		
ZIB41	Cal	X	X		
ZIB41	Data	X	X		
EIB42	Data		X		(hung galvo)
ZLP44	Data		X		
NLP45	Data		X		
Z61	Cal	X	X		
Z63	Cal	X	X		
Z65	Cal	X	X		
Z67	Cal	X	X		
Z69	Data				(power supply)
Z99	Cal	X	X		
Z99	Data	X	X		

a. All data circuits at both the vault and CRB ends except those instruments installed in the underground walk-in vaults;

b. All calibration circuits at the seismometer end except instruments housed in the underground vaults;

c. The seismometer end of all telephone circuits in the extended array.

A typical installation of the AEI protection system is shown in figure 5; an enlarged view of the AEI protectors is shown in figure 6.

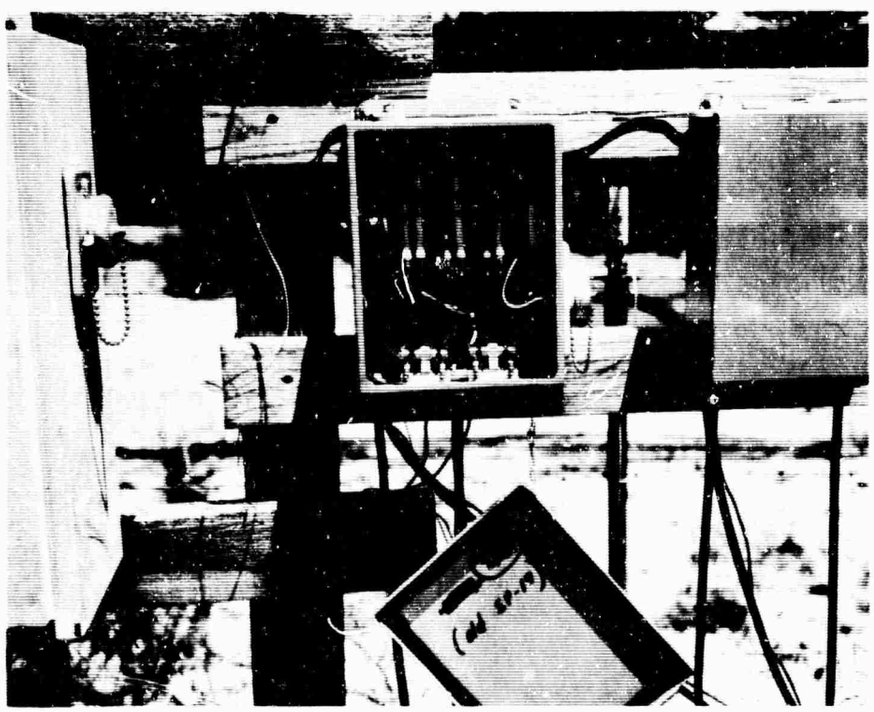

Figure 5. Modified protector bo... Z1

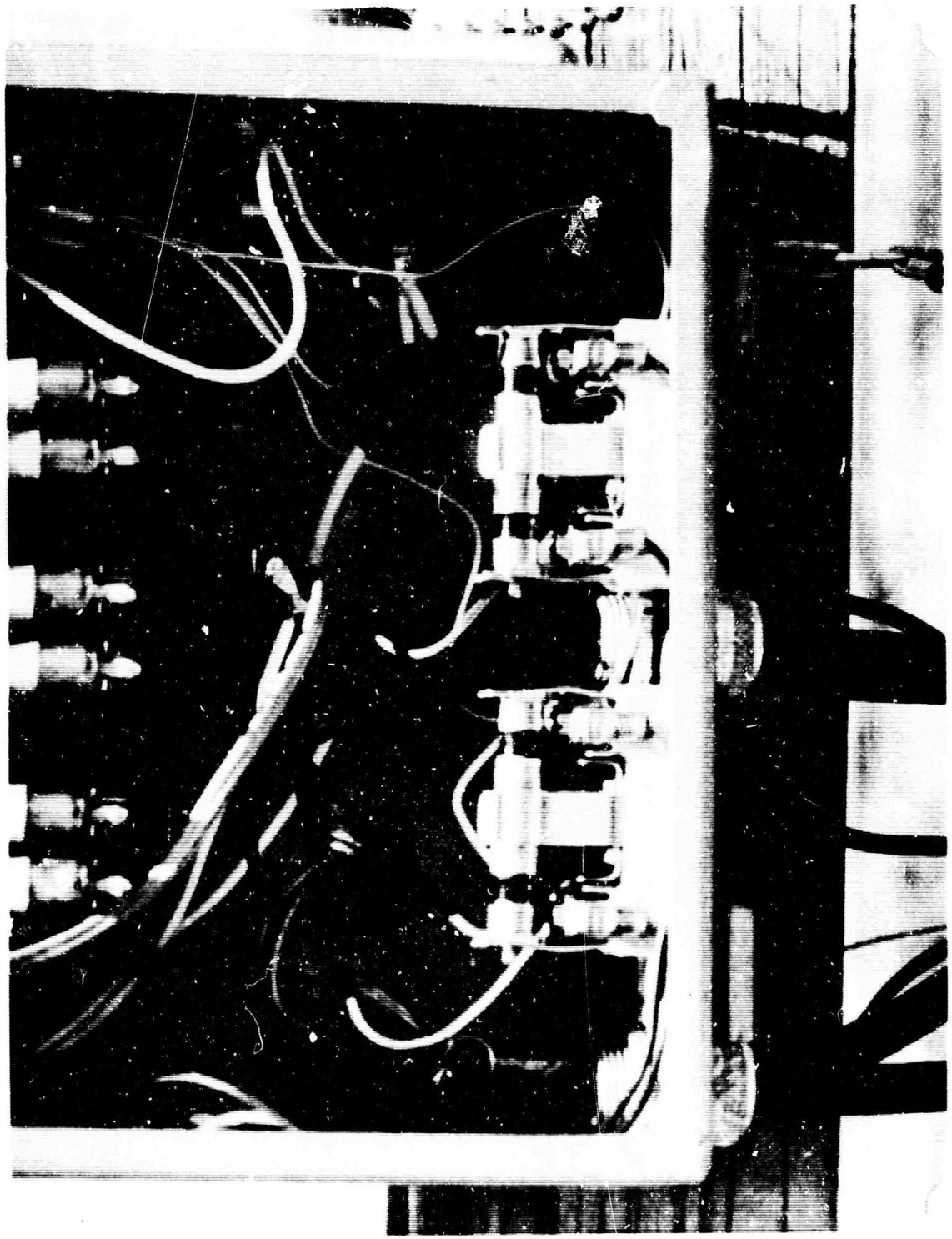

Figure 6. AEI protectors

2.2.3 Peristaltic Pumps for Develocorders

Nine new peristaltic pumps for the Develocorders were received 24 June, and installation was begun on 1 July. By the end of July, four of the pumps had been replaced in the Develocorders.

2.2.4 Long-Period System Change

Several attempts were made to adjust the instruments in the long-period systems to obtain the response reported for the long-period instruments prior to 1 May. The inability to obtain this response was traced to incorrect circuitry.

A thorough examination of the long-period circuitry at TFSO showed several discrepancies. The major discrepancies were:

a. Eighty-ohm attenuator circuits were mounted on the PTA's to control the system magnification. The long-period vertical PTA attenuator had been bypassed and a resistive network built inside the PTA. With these arrangements the correct galvanometer damping could not be obtained.

b. A line equalization and free period module was built into the line in order to adjust the seismometer damping, but the correct damping is not obtainable. In the vertical system, the line equalization module was bypassed.

c. UED type 651 galvanometers were used with the north and east long-period PTA's. These galvanometers tend to be quite unstable and frequently hang on a stop.

A recommendation is being prepared describing proposed modifications to the long-period system. Two of the major modifications proposed are (a) replacement of the UED type 651 galvanometers in the horizontal seismographs with more stable and more ideally damped Model 8530-1 Harris long-period galvanometers (110 sec); and (b) installation of Model 14415 junction assemblies in the PTA's of the three-component long-period seismograph system.

2.2.5 Marine Door for Long-Period Vault

The installation of a pressure-tight marine door for one of the pier rooms in the long-period vault at TFSO was approved by the Project Officer. The

marine equipment that met the design specifications and vault requirements has been located and ordered. Installation of the marine door at TFSO has been tentatively scheduled for mid-August.

2.2.6 Transmission of Routine Data Messages to USC&GS

At the request of the Project Officer, data messages are being sent from TFSO each day, including week-ends and holidays. Prior to 26 June, data messages to USC&GS were not sent on week-ends and holidays because the GSA facilities are not open and there is no Western Union office in Payson for direct transmission. On Saturday, 26 June, the message was typed at TFSO, delivered to the Mogollon Stage Line in Payson, and hand carried to the Western Union office in Phoenix for transmission to the USC&GS. By the following week-end the Project Officer had furnished a TWX number for USC&GS, and commencing with 3 July, week-end and holiday messages are sent directly to USC&GS by TWX.

2.2.7 Date Timer 4800A

One of the Develocorder Date Timer Group Assemblies, Model 4800, was shipped from TFSO to Geotech on 25 June for modification to a Model 4800A. Because a complete set of spare units is not available at TFSO, modification must be accomplished on a one-at-a-time basis. The first modified date timer and a spare date timer were sent to TFSO early in July and were installed. In general, the modified unit works well.

2.2.8 Five-Channel 35-Millimeter Film Recorder

In June, we received approval of our recommendation to delete the 2 Wood-Anderson seismographs from the 5-channel 35-mm film recorder and to add 2 Benioff vertical seismographs. Later we found that the film recorder could not be easily modified to record the earth-powered Benioff vertical data. The recorder was replaced with a Geotech Mark II 35-mm film recorder. The channel assignments of the seismographs being recorded and their approximate operating magnifications at 1 cps are as follows:

Earth-powered vertical	-	10K
Earth-powered vertical	-	1K
Earth-powered north	-	10K
Earth-powered east	-	10K

2.2.9 Weekly Polarity Check

A weekly polarity check of the TFSO instrumentation was established in May. The polarity check procedures are the same as those used at BMSO, UBSO, and WMSO.

2.2.10 Check of Station Parameters

At TFSO, 83 active data circuits are normally used. The instrumentation complement is comprised of 47 vertical short-period Johnson-Matheson (JM) instruments, 12 sets of horizontal short-period JM instruments, 1 three-component Benioff earth-powered system, 1 three-component intermediate-band system, 1 three-component broad-band system, and 1 three-component long-period system.

At the time Geotech began operating TFSO, the magnifications of the vertical JM instruments were held at 900K. The intermediate-band system operated at 200K, the broad-band system at 6K, the long-period vertical (notched) at 100K, the long-period vertical (un-notched) at 125K, and the long-period horizontals at 15K. The magnifications varied by a factor of as much as two from day to day on some of the individual instruments. Part of the trouble was traced to an isolation amplifier malfunction and part was due to burned carbon blocks in the lightning protection system.

Because lightning strong enough to cause carbon block problems can also change the instrument motor constant (G) values, a program was initiated early in May to check the G values and to make the monthly check of the frequency responses for the TFSO instrumentation.

Prior to 25 May, the following parameters were used to determine the magnification of the intermediate-band system:

Seismograph	Motor constant[1]	Equivalent ground motion	Magnification factor	Calibration current
ZIB (41)	0.105 N/A	200 mμ	5K/mm	0.40 ma
EIB (42)	0.144 N/A	200 mμ	5K/mm	1.12 ma
NIB (43)	0.138 N/A	200 mμ	5K/mm	1.12 ma

[1]Checked last on 9 December 1963; no shunting networks used in calibration lines

On 17 May, the intermediate-band system parameters were checked with the following results:

a. The intermediate-band vertical had a basic motor constant of 0.144 N/A using a 200-milligram weight. Basic computations indicated that the actual equivalent ground motion for a normal calibration was 560 mμ or a magnification factor of 1.8K/mm instead of the 5K/mm listed in the records.

b. The intermediate-band east-west had a motor constant of 0.178 N/A using a 200-milligram weight. The calculated magnification factor was 0.95K/mm instead of the 5K/mm listed in the records.

c. The intermediate-band north-south had a motor constant of 0.172 N/A using a 200-milligram weight. The calculated magnification factor was 0.98K/mm instead of the 5K/mm listed in the records.

The results of the check on 17 May indicate that, if the previously listed parameters were used to calculate gains, they would be approximately a factor of four greater than the actual gain.

On 24 May, the motor constants for the intermediate-band system were adjusted using resistive networks to obtain the parameters presently in use at TFSO:

Seismo-graph	Motor constant	Equivalent ground motion	Magnification factor	Calibration current
ZIB	0.0206 N/A	250 mμ	4.0K/mm	1.0 ma
EIB	0.0471 N/A	250 mμ	4.0K/mm	1.0 ma
NIB	0.0472 N/A	250 mμ	4.0K/mm	1.0 ma

All three components of the intermediate-band system are being operated at a gain of about 100K at 1 cps.

The motor constants of the JM short-period vertical and horizontal instruments were also checked. The following are the motor constants and calibration parameters for TFSO since 24 May:

Seismo-graph	Motor constant	Equivalent ground motion	Magnification factor	Cali-bration current	PTA attenu-ation
Z1-Z31	0.296 N/A	33.3 mμ	30K/mm	80 ma	-12 dB
H75-H98	0.386 to 0.411 N/A	Varies μ	30.6K/ to 33.9K/mm	60 ma	-12 dB
Z60-Z74	0.296 N/A	33.3 mμ	30K/mm	80 ma	-12 dB

The long-period system was modified to bring the instruments within the tolerances shown in figure 7 and the gain of the long-period vertical at 0.04 cps set at 65K.

During July, the system checks and frequency responses performed on the full complement of instrumentation at TFSO indicated that eight frequency responses were out of tolerance. Five of these were short-period seismographs, 1 was an intermediate-band seismograph, and 2 were broad-band seismographs. All of the system parameters and instrument frequency responses were within operating tolerances at the end of the reporting period.

2.3 ANALYZE DATA AND REPORT RESULTS TO USC&GS AND SEISMIC DATA LABORATORY (Tasks 1c and 1d)

2.3.1 Report Events to U.S. Coast and Geodetic Survey

During this reporting period, arrival times, periods, and amplitude measurements of events recorded at TFSO were reported daily to the Director of the USC&GS in Washington, D. C. The number of events recorded by type are as follows:

	Local	Near regional	Regional	Teleseism	Total
May	2	71	18	933	1024
June	3	128	21	991	1143
July	0	185	19	953	1157

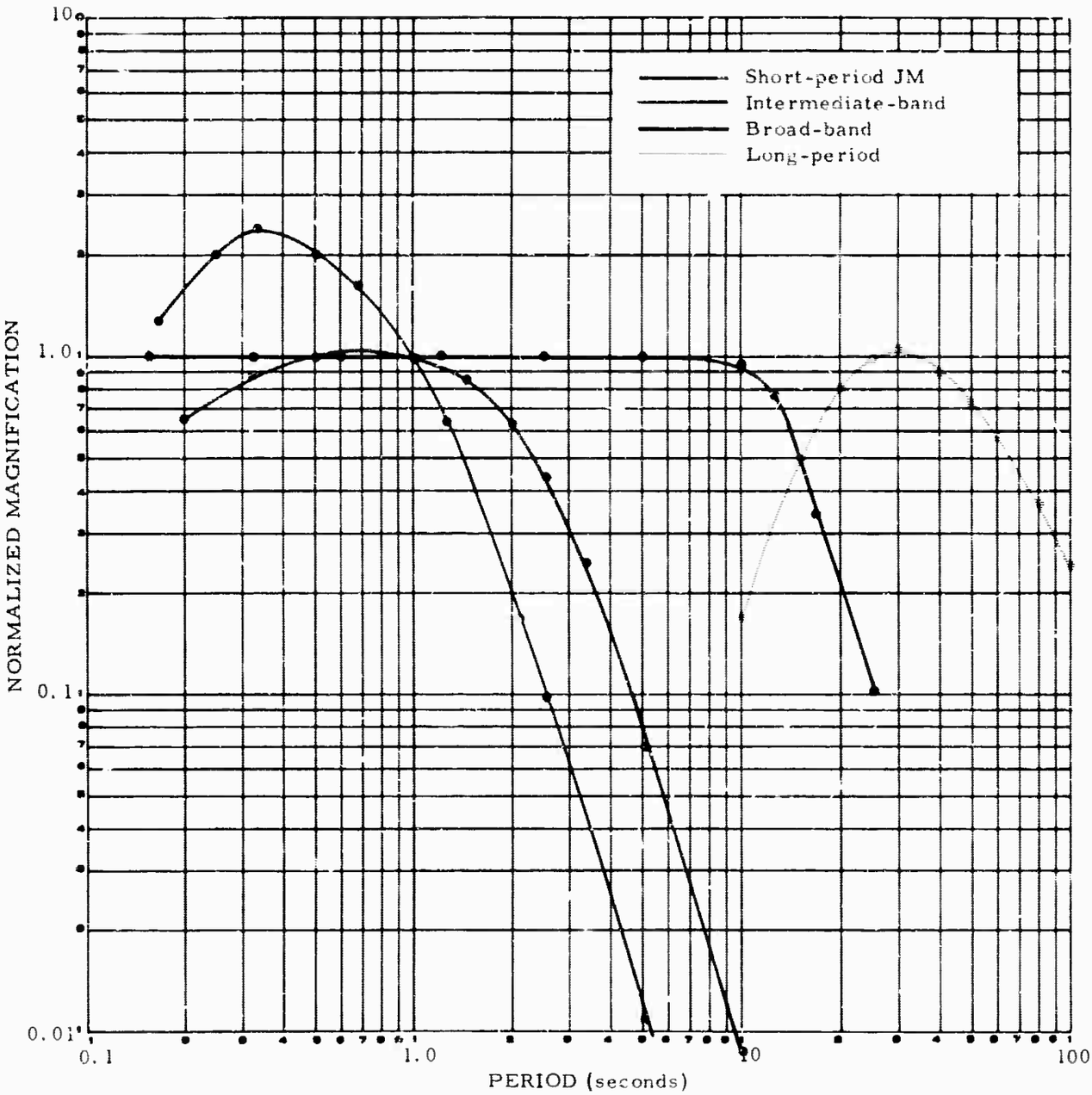

Figure 7. Normalized response characteristics of seismographs at TFSO

2.3.2 Change in Reporting pP

Prior to 28 June the USC&GS had requested that both confirmed and suspected depth phase (pP) arrivals be reported in our routine data messages. On 28 June, Mr. April of the USC&GS advised the Project Officer that they preferred that only those arrivals that could be definitely identified or for which there was reasonable confidence of their identification as pP be included in our messages.

2.3.3 Events Reported to SRI

The events given in table 2 were reported to Stanford Research Institute (SRI) during June and July.

On 27 July, Mr. Arthur Lange of SRI asked TFSO to suspend the reporting of earthquakes.

2.3.4 Daily Analysis for ABP

Data from TFSO were combined with the data from CPSO, BMSO, UBSO, and WMSO to be published in a multistation earthquake bulletin. The bulletins for December 1964 and January 1965 were published during the reporting period. Data for May have been keypunched, transcribed onto magnetic tape, and sent to SDL for processing. Keypunching of June data is about 60 percent complete.

2.4 QUALITY CONTROL (Task 1e)

Quality Control of the TFSO magnetic-tape seismograms, film seismograms, and logs is routinely undertaken at Garland. The quality control procedures are outlined in Technical Report 64-59, Standard Operating Procedures for Seismological Observatories.

2.5 TELEPHONE AND VHF TELEMETRY BETWEEN TFSO AND LRSM VANS (Task 1f)

2.5.1 Myrtle Point Generator Problem

The operation of the Lister generator (figure 8) which supplied power for the Myrtle Point relay station had not been satisfactory and caused a lot of

Table 2. Local events reported to SRI

03 June	162819.2	m_b = 4.3	Delta = 7.5°	N of Fresno, California
25 June	002045.5	m_b = 4.6	Delta = 7.0°	Central Nevada
27 June	192532.0	m_b = 4.0	Delta = 5.0°	Central Utah
30 June	074751.8	m_b = 4.0	Delta = 5.0°	Central Utah
30 June	131659.0	m_b = 3.5	Delta = 5.8°	Central Utah
05 July	171834.5	m_b = 3.4	Delta = 4.8°	Central Utah
13 July	180421.2	m_b = 3.9	Delta = 3.2°	Southwest Utah
14 July	082828.4	m_b = 3.8	Delta = 7.1°	Central Nevada
15 July	181241.1	m_b = 3.5	Delta = 4.9°	Utah
16 July	074751.4	m_b = 4.6	Delta = 6.8°	Bakersfield, California
18 July	035711.7	m_b = 3.6	Delta = 4.9°	Eastern Utah
18 July	065013.2	m_b = 3.5	Delta = 3.9°	Southern Utah
18 July	155912.8	m_b = 4.2	Delta = 4.1°	Southern California
	162447.2	3.2		
	164430.3	3.0		
	165524.6	3.0		
	170404.8	3.0		
18 July	171052.0	m_b = 3.3	Delta = 3.6°	Southern Utah
18 July	172822.7	m_b = 3.7	Delta = 3.7°	Southern Utah
18 July	210923.0	m_b = 4.1	Delta = 7.5°	Denver, Colorado, and three aftershocks

outage time. The disruption of data transmission was compounded by the remote location of the relay station. The Myrtle Point installation required approximately 350 gallons of diesel fuel per month and was generally inaccessible in the winter. On 6 May, 660 gallons of diesel fuel were hauled into Myrtle Point. The generator was shut down and general repairs made at that time. On 8 May, data transmission was lost because of a broken power cable at the generator due to vibration. A new cable with standard conductors was installed the same day and the generator repaired.

The generator operated continuously until 9 June when it again failed. The engine apparently developed an oil leak and used the 20-gallon oil reserve

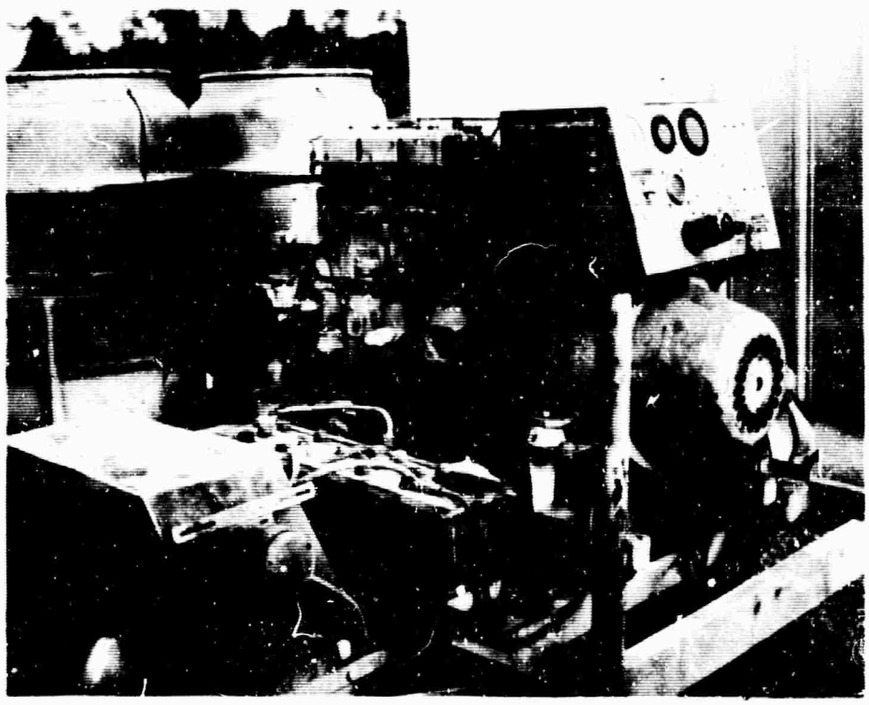

Figure 8. Lister diesel generator after removal from Myrtle Point

in a 3-week period. Damage to the engine resulted from overheating the bearings, causing a broken rod. A 5 kW gasoline-powered generator was rented and temporarily placed in service on 11 June.

A new 9 kW Witte diesel generator unit was ordered from Socorro, New Mexico, on 14 June and delivered on 15 June. On 15 June, a concrete pier 4 by 1.5 by 6 feet was poured. The generator was set up and installed on the pier on 16 June (see figure 9). The fuel consumption is estimated to be 6 to 8 gallons a day.

The generator has given no trouble since installation.

Figure 9. Witte diesel generator and pier at Myrtle Point

2.5.2 LRSM Generator Operation

The 1.5 kW generators at the Globe and Heber, Arizona, extended array sites were fueled during the first week in May. In July, cutoff problems were encountered with the two generators. Heat in the generator building probably caused the overheating cutoff switch to cut out. The problem has been remedied by better ventilation of the generator housing building.

2.5.3 TFSO-LRSM Telemetry System

Several LRSM Geotech personnel have visited TFSO to familiarize themselves with the observatory facilities and to maintain close coordination and cooperation between the two groups. One of the prime areas in the data collection program that requires TFSO-LRSM coordination is that of the daily and weekly calibrations.

2.5.4 Modification of Telephone Service by Mountain States Telephone Company

In the vicinity of TFSO, the telephone service is supplied by Mountain States Telephone Company. Messrs. R. Nelson and A. Elliott from Mountain States in Phoenix visited the TFSO facilities to gain a better understanding of the observatory requirements.

The telemetry system for data transmission between the LRSM teams and TFSO required four-wire telephone service, which was generally not available in the area. Mountain States Telephone started work on the four-wire termination system on 7 July and completed the installation on 10 July. Some signal-to-noise improvement could initially be noted.

2.5.5 Attenuators for Telemetry Data Input Levels

The Develocorder signal level input from the telemetry system was too high because no attenuation controls were available in the lines between the discriminators and the Develocorders. Because the output level from the discriminators is required to be equal to the recording levels normally maintained at TFSO, some method of control was necessary. Attenuator controls were installed in June and the data level inputs have been equalized.

2.5.6 Modification of the Data Acquisition System

After the recording of digital data for MIT was completed, modification of the Astrodata Data Acquisition System to provide 556 bpi digital packing density, instead of the original 800 bpi density, was investigated. Modification of the packing density is required in order to provide digital data suitable for processing by the CDC 1604 computer at SDL.

Modification of the Astrodata system at TFSO is in progress and should be complete about the middle of August.

2.6 PROVIDE FACILITIES AND ASSISTANCE TO OTHER GROUPS (Task 1g)

2.6.1 Digital Recording for Texas Instruments

Texas Instruments is conducting a study for which they require special digital data to be recorded at TFSO. The data are to be recorded over a 2-month period using the observatory instrumentation and data from the eight LRSM extended array sites. Data from both seismic events and seismic background noise at high and low gains will be recorded.

The program was scheduled to begin on 1 July but several problems developed. The Texas Instruments requirements for recording the low-gain data do not require any changes in the normal TFSO recording settings. The requirements specified by Texas Instruments for recording the high-gain data have posed the greatest problems and have delayed the recording program. High-gain recording is specified to drive the Astrodata equipment within 6 to 10 dB of clipping when recording the normal background noise. In order to record the data at this high gain, it is necessary to increase the signal level output of the LRSM equipment. The increased signal level was accomplished by the LRSM recording vans and at TFSO just ahead of the digital data acquisition system. The JM instruments were replaced by Benioff instruments in the three-component short-period system. In addition, it is required that the TFSO long-period response be comparable to the LRSM long-period response.

Because of the required modifications of the telemetry system and instrumentation parameters, full-scale recording for Texas Instruments has been postponed until the middle of August.

2.6.2 Recording for California Institute of Technology

Dr. Stewart Smith of Cal Tech and two of his graduate students visited the observatory on 21 May to specify new data formats and to establish liaison with Geotech personnel. In May, TFSO was recording data for Cal Tech on three magnetic-tape recorders and one Develocorder. The formats were continued until 1 July, when recording of a new series was started.

Dr. Smith was particularly interested in the analog-to-digital recording systems being used by MIT. He expressed a desire to use this equipment at some future date if it becomes available. Also discussed was the problem of maintaining matched horizontal instrument phase responses. We estimated that phase responses within ±4.5 degrees could be maintained for the JM horizontals.

Dr. Smith also requested that an experiment be done for him on a few signals involving a differential sum between two horizontal instruments.

Experimental recordings were made on 16, 21, and 22 July using film data trunk 10 by request of Dr. Smith. The three-component short-period system consisting of Z 13, NE 90, and SE 89 was recorded side by side with a direct summation of NE 90 and SE 89.

2.6.3 Recording for University of California

Mr. D. Miller, University of California, requested approval to move some equipment including an Ambilog 200 computer system to TFSO and that 32 channels of data be made available for his use. On 25 May, Mr. Foulks of the University of California began making some necessary interval wiring modifications at TFSO prior to the arrival of the equipment. Mr. Miller and Dr. H. M. Iyer visited TFSO on 1 June to prepare for the arrival of the equipment on 2 June.

Dr. R. A. Haubrich and Mr. Miller visited TFSO on 1 July and returned again on 15 July. The Ambilog 200 system is currently in operation and Dr. Haubrich is engaged in "on-line" processing of TFSO data and extended array data. Dr. Haubrich anticipates completion of most of his recording about the middle of August.

2.6.4 Recording for Massachusetts Institute of Technology

Between 1 May and 1 July, a Teledyne operator recorded digital seismic data from the LRSM extended array and from TFSO for MIT. Some problems were encountered with the Astrodata discriminators early in May. After modifications of the discriminators by Astrodata and completion of the air conditioning of the engineering laboratory at TFSO, the operating problems were corrected.

Beginning 1 July, the responsibility for operation of the telemetry equipment, digital recording equipment, and data acquisition system was transferred to TFSO.

2.6.5 Visits by Dr. Yale and Students

Dr. Yale of Arizona State University has visited TFSO twice, first on 3 July with 36 elementary education students, and then on 10 July with 32 elementary education students. Each time Dr. Yale and the students were given a tour of the observatory and a brief lecture on seismology.

2.6.6 Phoenix Television and Newspaper

During the morning of 10 May, Channel 5 television station at Phoenix requested confirmation of a small local earthquake in the Phoenix area. No confirmation could be found on the TFSO records.

Mr. Neachy and Mrs. Marting from the Arizona Republic newspaper in Phoenix were visitors on 4 June. They were interested in writing a feature story about TFSO. Their request was reported to the Project Officer, and they were advised to contact the Public Information Officer of DASA for approval.

2.6.7 Visit by Maryvale High School Students

A group of 8 students and 2 instructors from Maryvale High School, Phoenix, visited TFSO on 8 May. They were given an explanation of the routine operation of the observatory and a general tour.

2.7 MAINTAIN TFSO FACILITIES (Task 11)

2.7.1 Engineering Lab

Work on air conditioning the engineering laboratory was started on 11 May and finished on 28 May. This work, planned and begun under the previous contract, included lowering the ceiling, insulating, and installing two 5-ton air-conditioning units and the required duct work.

The Project Officer requested that the TFSO engineering laboratory be designated as a "clean" room and be used for equipment and work requiring a controlled environment. Hopefully, the level of environmental noise recorded on the magnetic-tape systems will be reduced.

The conversion of the engineering laboratory to a clean room was completed on 9 July. All of the air-conditioning ducts have been equipped with air filters; the outside door and windows have been sealed and locked; doors into the darkroom and drafting areas are to be kept closed; no smoking is permitted; and all dust-creating materials have been removed. Daily maintenance is performed on the floor, equipment, racks, and work benches to maintain as stable a set of environmental conditions as possible.

2.7.2 Air Chiller Problem and Solution

During a visit by Mr. W. Grimpe, an engineer from ASD, on 27 April, he noted the continual buildup of scale in the chiller units of the air-conditioning system caused by excessive quantities of minerals in the local water supply. Prior to May 1965, about every 6 months a heavy acid treatment was used to remove the scale. This was done by a Phoenix firm and was quite expensive. In addition to the cost, another undesirable feature of the continual use of the heavy acid was that the chiller units cannot withstand many such treatments before a complete replacement of the chillers, heat exchangers, etc., would be required.

At Mr. Grimpe's suggestion, a water treatment firm was requested to investigate the scaling problem and make recommendations. Sullbrook Services, Phoenix, made a water analysis and recommended chemicals which should eliminate the necessity of periodic cleaning and inhibit scale accumulation. A 5-month supply of the recommended chemicals and a feeder were purchased. Sullbrook Services guaranteed that they will provide a free acid treatment and scale removal if their product is not successful.

2.7.3 Furnace and Moisture Problem

On 27 April, Mr. Grimpe indicated that the boiler for the heating system, which had visible evidence of overheating, must be repaired or replaced.

A moisture problem is created, especially during the winter, by moisture condensing on the underside of the metal roof deck. The condensation is due to the absence of an adequate vapor barrier on the warm side of the insulation. Mr. Grimpe recommended that some sort of attic ventilation be installed as a solution to the moisture problem.

3. DEVELOPMENTAL FUNCTION (Task 3)

Mr. George Gray, Geotech, visited TFSO from 6 July through 9 July for general orientation of the facilities and, in particular, to obtain information for investigating the feasibility of automatic calibration.

4. RESEARCH PROGRAMS (Task 4)

4.1 CONTINUE NOISE SURVEYS

Monthly noise surveys are being conducted at TFSO as part of the standard observatory analysis assignment. Some confusion existed at the time of the personnel changeover at TFSO due mainly to the somewhat different noise study procedures existing between the two companies. These problems were resolved early in May and the noise measurements are being kept current.

4.2 SPECIAL STUDIES FOR AFTAC

For the first five days in May, Captain Houston requested that TFSO make a basic analysis of the teleseismic signals recorded on all the short-period verticals being used in the telemetry system. Included in the analysis were the P-wave arrival time, period, and amplitude of these signals.

Captain Munzlinger requested that on 14 July a special 24-hour recording be made of the tape data on trunk 6 and the film data of trunk 10. The data recorded consisted of TFSO Z16, ΣA1, WO-AZ Z1, WO-AZ Σ2-7, JR-AZ Z1, JR-AZ Σ2-7, station time, and WWV. The data were recorded as requested and mailed on 17 July.

4.3 MAGNITUDE CORRECTION FACTORS

On 23 July, we submitted an outline and requested approval of a planned study designed to refine the estimates of station magnitude correction factors developed under Project VT/036 and reported in TR 64-123, and to refine the distance-depth magnitude correction factors developed by Gutenberg and Richter. We plan to conduct this study jointly under Projects VT/5054 and VT/5055 using teleseismic P-phase data recorded at the five VELA-Uniform seismological observatories.

4.4 EVALUATE COMBINATIONS OF EXISTING VERTICAL AND HORIZONTAL ARRAYS

4.4.1 Some experimental recordings were made at TFSO between 5 July and 15 July. The purposes of the recordings were:

a. To determine the optimum magnifications for TFSO's short-period seismographs;

b. To compose an effective summation consisting of at least 8 less verticals than the present 31 instrument summation being recorded;

c. To evaluate filter settings to determine a better summation filter trace using a Krohn-Hite filter.

4.4.2 The preliminary results derived from records of the 10-day recording period are as follows:

a. Four short-period instruments were operated at magnifications ranging from 1000K to 1500K. The best operational magnification was apparently 1000K for the observed microseismic background.

b. During the recording period there were some problems with vaults which kept the instruments in the array from being accurately calibrated; however, the magnifications of the array elements were equal relative to each other. In the first few array configurations recorded, the preliminary results indicate that there were no significant differences in the signal-to-noise ratios of the summations tested.

c. Attempts were made to record the summation of Z1-Z31 trace filtered with a Krohn-Hite filter and the same summation with the standard operational filter. In the short recording period no conclusions could be made, but the results did indicate that further evaluation is necessary.

As soon as adequate equipment is available, we plan to resume this test program.

APPENDIX to TECHNICAL REPORT NO. 65-96

STATEMENT OF WORK TO BE DONE

STATEMENT OF WORK TO BE DONE
AFTAC PROJECT AUTHORIZATION NO. VELA T/5055 NOV 1 0 1964

1. Operation.

a. Operate the Tonto Forest Seismological Observatory (TFSO), normally recording data continuously.

b. Evaluate the seismic data to determine optimum operational characteristics and make changes in the operating parameters as may be required to provide the most effective observatory possible. Addition of new and modification of present on-line instrumentation are within the scope of work. However, such instrument additions and modifications, data evaluation, and major parameter changes are subject to prior technical approval by the AFTAC project officer.

c. Conduct routine daily analysis of seismic data and transmit daily seismic reports to the US Coast and Geodetic Survey, Washington, DC 20230, using the established report format and detailed instructions.

d. Record the results of daily analysis in a format compatible with the automated bulletin program (ABP) used by the Seismic Data Laboratory (SDL), 300 North Washington Street, Alexandria, Virginia 22314, in their preparation of the seismological bulletin of the VELA-UNIFORM seismological observatories. This format may be established by coordination with SDL through the AFTAC project officer. The schedule of routine shipments of this data to SDL will be established by the AFTAC project officer.

e. Conduct quality control (QC), as necessary, to assure the recording of high quality data on both magnetic tape and film. Past experience indicates that QC review of one magnetic tape per magnetic tape recorder per week is satisfactory unless QC tolerances have been exceeded and the necessity of additional QC arises. QC of magnetic tape should include, but need not necessarily be limited to, the following items:

(1) Completeness and accuracy of operation logs.

(2) Accuracy of observatory measurements of system noise and equivalent ground motion.

(3) Quality and completeness of voice comments.

(4) Examination of all calibrations to assure that no clipping occurs.

(5) Determination of relative phase shift among all array seismograph systems.

(6) Measurement of DC unbalance.

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(7) Presence and accuracy of tape calibration and alignment.

(8) Check of uncompensated noise on each channel.

(9) Check of uncompensated signal-to-noise of channel 7.

(10) Check of general strength and quality of WWV time.

(11) Check of synchronization of digital time code with WWV.

f. Continue telephone service and VHF telemetry between TFSO and the mobile seismic vans (Project VELA T/4051) located along extensions of the TFSO crossed array.

g. Provide observatory facilities, accompanying technical assistance by observatory personnel, and seismological data to requesting organizations and individuals after AFTAC approval through the project officer.

h. Maintain, repair, protect, and preserve the facilities of TFSO in good physical condition in accordance with sound industrial practice.

2. Instrument Evaluation.

a. On approval by the AFTAC project officer, evaluate the performance characteristics of experimental and off-the-shelf equipment offering potential improvement in the performance of observatory seismograph systems. Operation and test of the instrumentation under field conditions should normally be preceded by laboratory test and evaluation.

b. To permit more thorough laboratory evaluations to be conducted at TFSO, improvements to TFSO laboratory capability may be necessary. The contractor should make recommendations for such improvements and, after approval by the AFTAC project officer, implement them.

3. Developmental Function. Operation and evaluation of the observatory's "standard" instrumentation and of "experimental" equipment may disclose the need for supplemental equipment, neither commercially available nor in development under the VELA-UNIFORM program, that could improve the performance and capability of the seismograph systems of TFSO and other VELA-UNIFORM observatories. The contractor should make recommendations on the development of such equipment and, after approval by the AFTAC project officer, proceed with developmental work.

4. Research Programs. On approval by or at the request of the AFTAC project officer, conduct research programs designed to upgrade the TFSO detection capability. Environmental conditions (geological, seismological, and meteorological) affecting the results of these research programs should not be neglected. Research might pursue investigations in, but are not necessarily limited to, the following areas of interest:

a. Microseismic Noise.

(1) Review all available TFSO noise data to guide the direction of additional work. Define and conduct additional surface noise studies as necessary.

(2) Examine noise at shallow depths using existing and additional shallow boreholes. The number, depth, and locations of the additional boreholes must be approved by the AFTAC project officer.

b. Array Detection Capability.

(1) Evaluate combinations of existing vertical and of existing horizontal surface array seismographs to determine the most effective array summations in detecting teleseismic signals. Determine TFSO overall detection capability when using these array summations along with the remaining seismograph systems.

(2) Under Project VELA T/5052, AFTAC has programmed the addition of a multiple array processor to the TFSO instrumentation for the summer of 1965; training in operation, maintenance, and calibration of the processor and in analysis techniques will be provided to appropriate TFSO personnel at the time of installation by the manufacturer, Texas Instruments Incorporated. Evaluate the detection capability of the processor and examine its enhancement, if any, of the overall TFSO capability.

(3) Mobile seismic vans (Project VELA T/4051) are temporarily located along extensions of the TFSO crossed array and the data (3-component short-period) from the vans are recorded at TFSO. Investigate the use of this extended array to improve the TFSO detection capability.

(4) Determine TFSO deficiencies, if any, that degrade the observatory's detection capability. Prepare and submit to the AFTAC project officer recommended improvements designed to eliminate such deficiencies and enhance the detection capability.

c. Visual Data Presentation. Investigate forms of visual data presentation which would improve detection of seismic signals by visual on-line analysis.

Programs implemented should be planned for completion during the contracted period of TFSO operation. Furthermore, prior to commencing any research program, AFTAC approval must be obtained of a comprehensive outline for each research program instituted.